

CSC 591

Systems Attacks and Defenses

Web Security

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(Derived from slides by Giovanni Vigna and Adam Doupe)

HTML

- Original HTML had
 - images
 - tables
 - font sizes
 - ...
- Content was static





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HTML Design

- HTML designed to describe a text document with hyperlinks to other documents
- How to do fancy animations or pretty web pages?



JavaScript

- Client-Side scripting language for interacting and manipulating HTML
- Created by Brendan Eich at Netscape Navigator 2.0 in September 1995 as "LiveScript"
- Renamed to "JavaScript" in December 1995 and is (from the Netscape Press Release)
 - "announced JavaScript, an open, cross-platform object scripting language for the creation and customization of applications on enterprise networks and the Internet"
- JavaScript is a (from wikipedia) "prototype-based scripting language with dynamic typing and first-class functions"
 - Does this sound like Java?
- Questions over why the name change
 - Marketing ploy to capitalize on the "hot" Java language?
 - Collaboration between Sun and Netscape?
- By August 1996, Microsoft added support for JavaScript to Internet Explorer
 - Microsoft later changed the name to JScript to avoid Sun's Java trademark
- Submitted to Ecma International for standardization on November 1996
- ECMA-262, on June 1997, standardized first version of ECMAScript



JavaScript

- Lingua franca of the web
- Eventually supported by all browsers
- Language organically evolved along the way

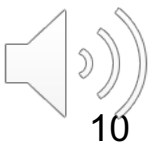


JavaScript

- Code can be embedded into HTML pages using the script element and (optionally storing the code in HTML comments)

```
<script>
<!--
var name = prompt('Please enter your name below.', '');
if (name == null) {
    document.write('Welcome to my site!');
}
else {
    document.write('Welcome to my site ' + name + '!');
}
-->
</script>
```

```
<script type="text/javascript">
<script language="javascript">
```





This page says: ×

Please enter your name below.

Cancel OK





This page says:

Please enter your name below.

Cancel

OK



test.html



Alexandros

← → ↻ ⓘ file:///tmp/test.html



Welcome to my site admin!



JavaScript

- You can also include external JavaScript files in your HTML
 - As opposed to the inline JavaScript that we saw in the previous example
- `<script src="absolute or relative URL"></script>`
- When the browser parses this HTML element, it automatically fetches and executes the JavaScript before continuing to parse the rest of the HTML
 - Semantically equivalent as if the JavaScript was directly in the page

Document Object Model (DOM)

- The Document Object Model is a programmatic interface in JavaScript to the manipulation of client-side content
- Created a globally accessible in JavaScript document object
 - The document object is used to traverse, query, and manipulate the browser's representation of the HTML page as well as handle events
- DOM 0, released in 1995 with original JavaScript
 - Very basic
- Intermediate DOM began in 1997 with Microsoft and Netscape releasing incompatible improvements to DOM
- W3C stepped in and started to define standards
 - DOM 1, October 1998
 - DOM 2, November 2000
 - DOM 3, April 2004
 - DOM is now a W3C Living Standard, and various snapshots of the standard will turn into [DOM4](#)

DOM Example

```
<!DOCTYPE html>
<html>
  <head>
    <meta charset="UTF-8">
    <title>DOM Example</title>
  </head>
  <body>
    <h1>DOM Example</h1>
    <div id='insert_here'>
    </div>
  </body>
  <script>
    var hr = document.createElement('HR');
    document.getElementById('insert_here').appendChild(hr);
  </script>
</html>
```



DOM Example

Using the DOM

- Coding proper DOM access in a cross-browser approach is a nightmare
 - Some highlights from <http://stackoverflow.com/questions/565641/what-cross-browser-issues-have-you-faced>
 - "Internet Explorer does not replace ` ` or HTML char code 160, you need to replace its Unicode equivalent `\u00a0`"
 - "In Firefox, a dynamically created input field inside a form (created using `document.createElement`) does not pass its value on form submit."
 - "`document.getElementById` in Internet Explorer will return an element even if the element name matches. Mozilla only returns element if id matches."
- jQuery is an amazing library that provides a uniform interface and handles all the DOM cross-browser compatibilities
- Today the situation is much better and compatibility has greatly improved

Browser Object Model (BOM)

- Programmatic interface to everything outside the document (aka the browser)
- No complete standard (the term BOM is colloquial)
- Examples
 - `window.name = "New name"`
 - `window.close()`
 - `window.location = "http://example.com"`

JavaScript vs. DOM and BOM

- JavaScript the language is defined separate from the DOM and BOM
 - DOM has its own specification, and much of the BOM is specified in HTML5 spec
- In the web context, these are often confused, because they are used together so often
- However, now with JavaScript popping up all over the place, it's an important distinction
 - Server-side code using Node.js
 - Database queries (MongoDB)
 - Flash (ActionScript, which has its own DOM-like capabilities)
 - Java applications (javax.script)
 - Windows applications (WinRT)

JavaScript – Object-based

- Almost everything in JavaScript is an object
 - Objects are associative arrays (hash tables), and the properties and values can be added and deleted at run-time

```
var object = {test: "foo", num: 50};  
object['foo'] = object;  
console.log(object[object['test']]);  
object.num = 1000;  
console.log(object['num']);
```

```
> var object = {test: "foo", num: 50};
< undefined
> object['foo'] = object;
< ▼ Object {test: "foo", num: 50, foo: Object} ⓘ
  ► foo: Object
    num: 1000
    test: "foo"
  ► __proto__: Object
> console.log(object[object['test']]);
  ► Object {test: "foo", num: 50, foo: Object}
< undefined
> object.num = 1000;
< 1000
> console.log(object['num']);
  1000
< undefined
>
```

JavaScript – Recursion

```
function factorial(n) {  
    if (n === 0) {  
        return 1;  
    }  
    return n * factorial(n - 1);  
}  
console.log(factorial(5));  
120
```

JavaScript – Anonymous Functions and Closures

```
var createFunction = function() {  
    var count = 0;  
    return function () {  
        return ++count;  
    };  
};  
  
var inc = createFunction();  
inc();  
inc();  
inc();  
  
var inc2 = createFunction();  
inc2();
```



```
> var createFunction = function() {  
    var count = 0;  
    return function () {  
        return ++count;  
    };  
};  
< undefined  
> var inc = createFunction();  
< undefined  
> inc();  
< 1  
> inc();  
< 2  
> inc();  
< 3  
> var inc2 = createFunction();  
< undefined  
> inc2();  
< 1  
>
```

JavaScript – Runtime Evaluation

- JavaScript contains features to interpret a string as code and execute it
 - eval
 - Function
 - setTimeout
 - setInterval
 - execScript (deprecated since IE11)

```
var foo = "bar";  
eval("foo = 'admin';");  
console.log(foo);  
var x = "console.log('hello');";  
var test = new Function(x);  
test();
```



```
> var foo = "bar";
```

```
< undefined
```

```
> eval("foo = 'admin';");
```

```
< "admin"
```

```
> console.log(foo);
```

```
admin
```

VM49:1

```
< undefined
```

```
> var x = "console.log('hello');";
```

```
< undefined
```

```
> var test = new Function(x);
```

```
< undefined
```

```
> test()
```

```
hello
```

VM54:2

```
< undefined
```

```
>
```



JavaScript Uses – Form Validation

- How to validate user input on HTML forms?
- Traditionally requires a round-trip to the server, where the server can check the input to make sure that it is valid

JavaScript Uses – Form Validation

```
<?php
if ($_GET['submit']) {
    $student = $_GET['student'];
    $class = $_GET['class'];
    $grade = $_GET['grade'];
    if (empty($student) || empty($class) || empty($grade)) {
        echo "<b>Error, did not fill out all the forms</b>";
    }
    else if (!(($grade == 'A' || $grade == 'B' || $grade == 'C' ||
        $grade == 'D' || $grade == 'F')) {
        echo "<b>Error, grade must be one of A, B, C, D, or F</b>";
    }
    else { echo "<b>Grade successfully submitted!</b>";
    }
} ?>
```

```
<form>
Student: <input type="text" name="student"><br>
Class:   <input type="text" name="class"><br>
Grade:   <input type="text" name="grade"><br>
<input type="submit" name="submit">
</form>
```

Quick tip:

```
$ cd /var/www/public_html
$ php -S localhost:8000
```



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localhost:8000/test.php ✕

Alexandros

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Student:

Class:

Grade:

Submit

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localhost:8000/test.php ✕

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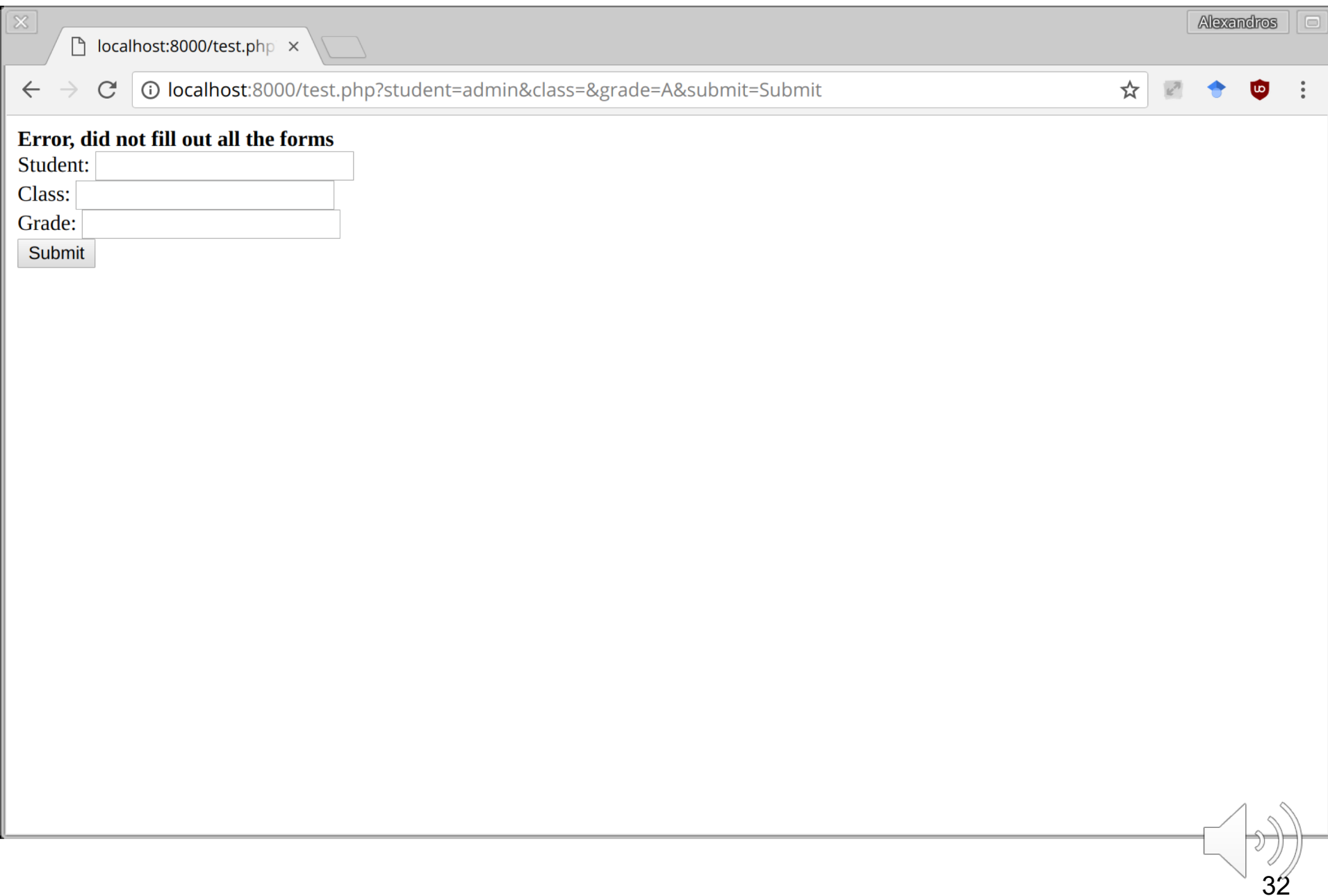
Student:

Class:

Grade:

🔊

31



localhost:8000/test.php x

localhost:8000/test.php?student=admin&class=&grade=A&submit=Submit

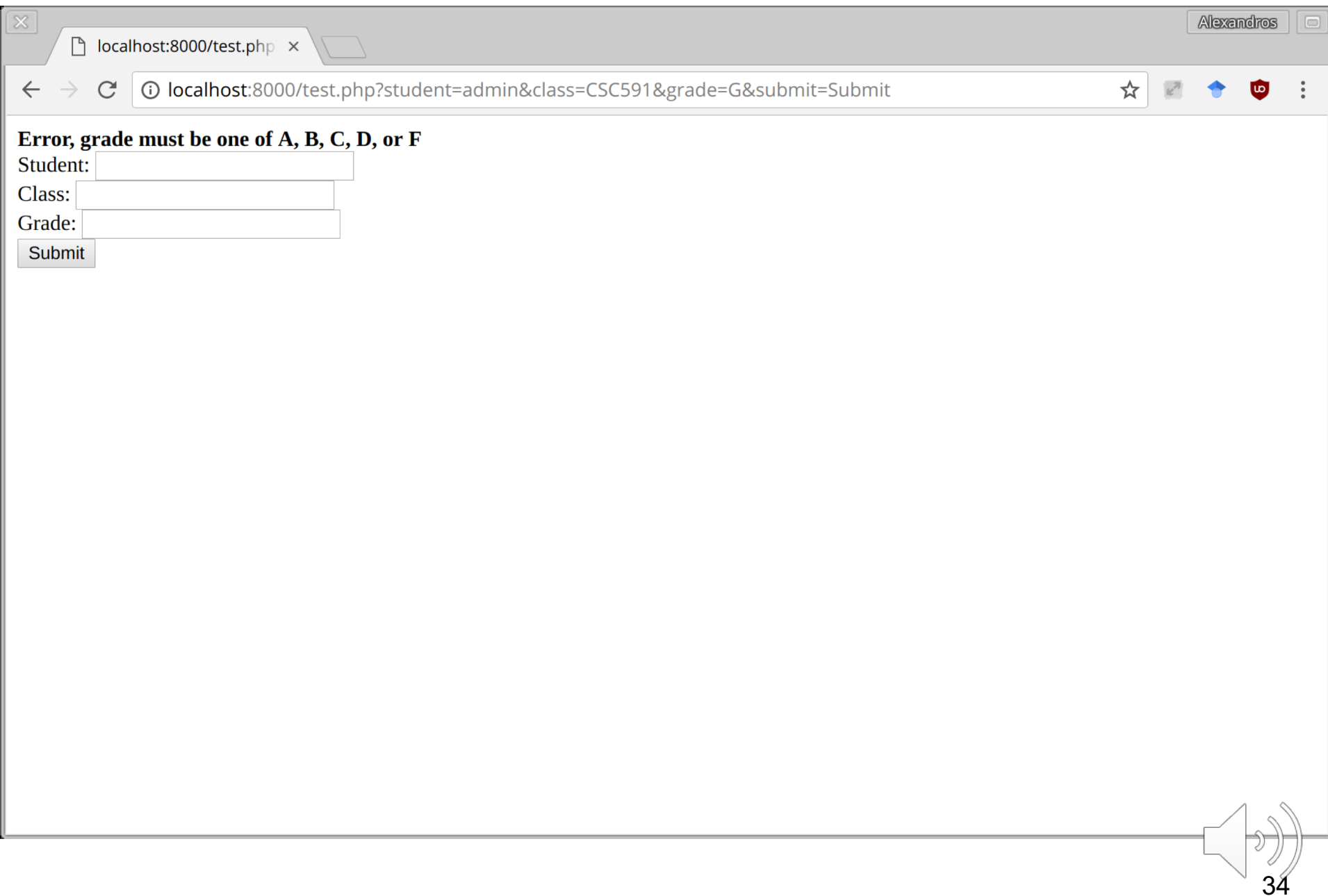
Error, did not fill out all the forms

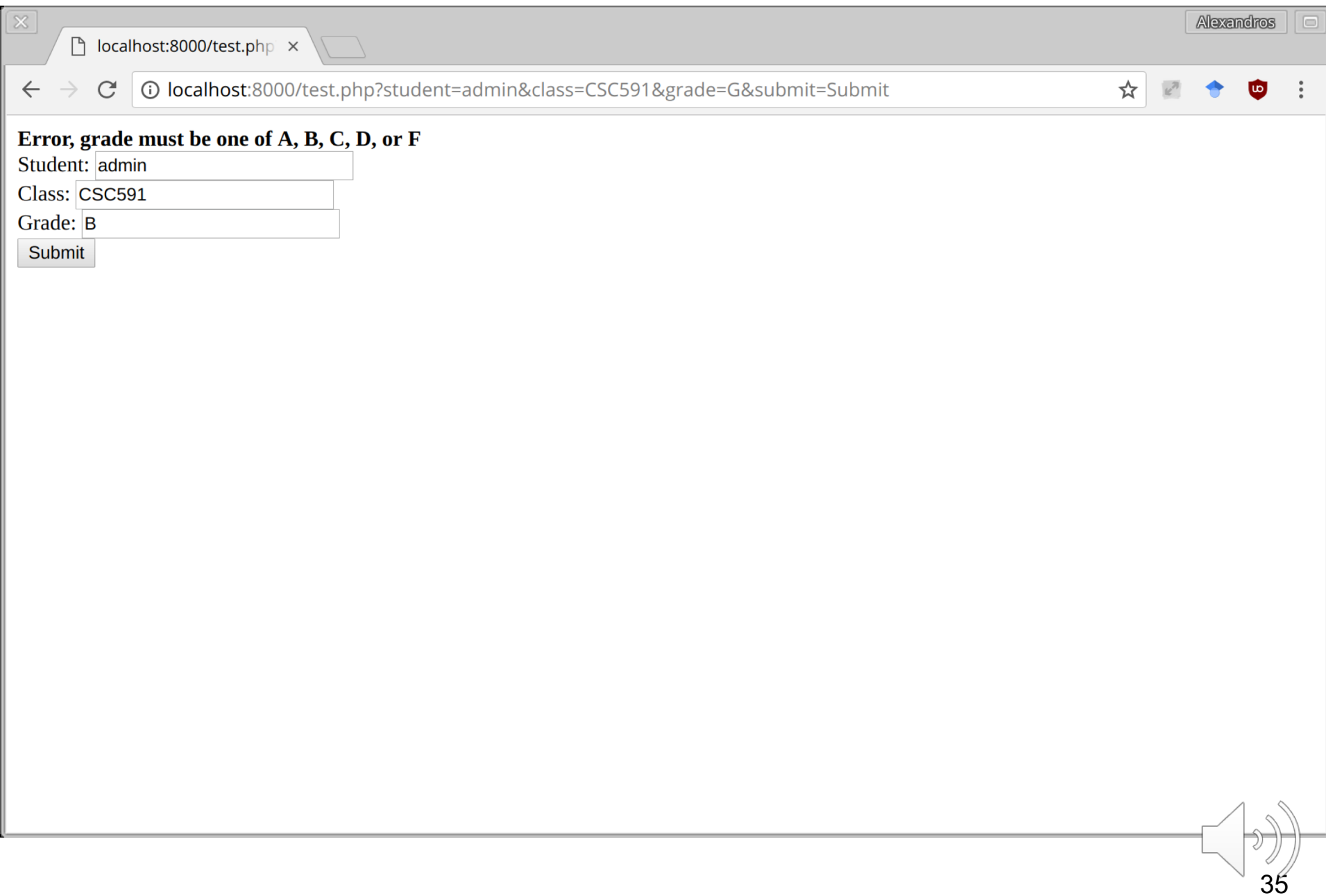
Student:

Class:

Grade:

33





localhost:8000/test.php

Alexandros

localhost:8000/test.php?student=admin&class=CSC591&grade=B&submit=Submit

Grade successfully submitted!

Student:

Class:

Grade:

Submit

36



`form_validation_regular.php`



`empty class field`



`wrong grade format`



`correct submission`



JavaScript Uses – Form Validation

```
<script>
function check_form() {
    var form = document.getElementById("the_form");
    if (form.student.value == "" || form.class.value == "" || form["grade"].value == ""){
        alert("Error, must fill out all the form");
        return false;
    }
    var grade = form["grade"].value;
    if (!(grade == 'A' || grade == 'B' || grade == 'C' ||
        grade == 'D' || grade == 'F')) {
        alert("Error, grade must be one of A, B, C, D, or F");
        return false;
    }
    return true;
}
</script>
<form id="the_form" onsubmit="return check_form()">
    Student: <input type="text" name="student"><br>
    Class: <input type="text" name="class"><br>
    Grade: <input type="text" name="grade"><br>
    <input type="submit" name="submit">
</form>
```



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localhost:8000/test.php ✕

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Student:

Class:

Grade:

Submit

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localhost:8000/test.php ✕

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Student:

Class:

Grade:



localhost:8000/test.php

localhost:8000/test.php

Student:
Class:
Grade:

localhost:8000 says:
Error, must fill out all the form

OK

✕

localhost:8000/test.php ✕

Alexandros


← → ↻ ⓘ localhost:8000/test.php ☆

Student: admin

Class: CSC591

Grade: G

Submit



localhost:8000/test.php

localhost:8000/test.php

Student:
Class:
Grade:

localhost:8000 says:
Error, grade must be one of A, B, C, D, or F

OK

✕

localhost:8000/test.php ✕


Alexandros

← → ↻ ⓘ localhost:8000/test.php ☆

Student:

Class:

Grade:


44

localhost:8000/test.php

Alexandros

localhost:8000/test.php?student=admin&class=CSC591&grade=B&submit=Submit

Grade successfully submitted!

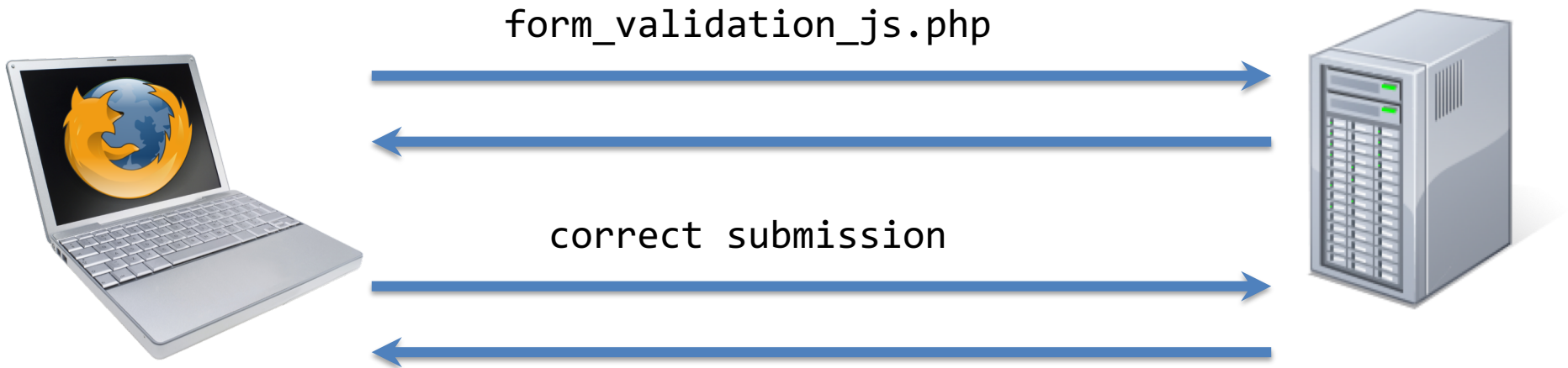
Student:

Class:

Grade:

Submit

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Client-Side Validation

- Now that we're doing validation on the client, can we get rid of all those PHP checks in our server-side code?
 - No!
 - No guarantee that client-side validation is performed
 - User disables JavaScript
 - Command-line clients
- Otherwise, users could enter arbitrary data that does not conform to your validation
 - Could lead to a security compromise or not
- So the validation must remain on the server-side and the client-side
 - Brings up another problem, how to perform consistent validation when server-side and client-side written in different languages